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PATENT SPECIFICATION

DRAWINGS ATTACHED

L138.011

L138.011



Date of Application and filing Complete Specification: 23 June, 1966.

No. 29023/66.

Application made in United States of America (No. 469649) on 6 July, 1965.

Complete Specification Published: 27 Dec., 1968.

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Index at acceptance: —B6 A 42A

Int. Cl.: —B 41 m 3/14

COMPLETE SPECIFICATION

Improvements in Printed Matter for the Purpose of Rendering Counterfeiting more Difficult

We, CANADIAN BANK NOTE COMPANY LIMITED, whose full post office address is Box 394, 145 Richmond Road, Ottawa, Ontario, Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to improvements in printed matter for the purpose of rendering counterfeiting more difficult.

Important documents such as bank notes, share certificates and the like are printed in such a manner that the document cannot be easily reproduced by counterfeiters. For example, bank notes are usually printed by an intaglio printing process in which the quantity of ink deposited on the bank note may be varied so as to create variations in shade or "tone" of the colour of the configurations on the bank note.

Developments in photo-mechanical reproduction methods using half-tone screening processes have made possible fairly good coloured reproductions of original documents. While persons very familiar with an original document such as a bank note (e.g. bank tellers) may be able to detect counterfeit reproductions even when skillfully made by photo-mechanical methods, persons making only casual inspection of such documents may not be able to detect a counterfeit document.

According to the present invention printing matter is provided with one or more patterns or configurations which prevent successful counterfeiting by half-tone screening reproduction processes by virtue of the intersection of the patterns on the printed matter with the rectangular screen grid pattern of the half-tone reproduction screen so as to make it substantially impossible to avoid

creating a Moiré pattern on the reproduced document. The Moiré pattern, if conspicuous enough, will warn the observer that the copy is not genuine. The kinds of printed matter with which the present invention is particularly concerned include any multiply printed documents of commercial value to which patterns are applied, such as bank notes, identity cards, travellers' cheques, postage stamps, and share certificates.

The present invention makes use of the fact that in obtaining colour-separations from a coloured original, light emanating from a continuous-tone negative (or more rarely, positive) is intercepted by a screen in order to create a half-tone positive (or negative, as the case may be). It is the interaction of the screen with the pattern on the original that results in the creation of a Moiré pattern, as will be more fully explained below. For example, assuming that a counterfeiter uses a half-tone screen having a grid spacing of 100 lines per inch, a bank note bearing a configuration of parallel straight lines having a spacing approximately 100 lines per inch will, if the angle of intersection of the screen lines with the bank note lines is small enough, produce a Moiré pattern. However, the bank note manufacturer cannot assume that the half-tone screen used by the counterfeiter will have any given line spacing nor can it assume that any given screen orientation will be used. According to the invention the original document is provided with one or more patterns selected so that, when light therefrom is intercepted by a rectangular half-tone screen, then regardless of the orientation of the screen selected by the counterfeiter a perceptible Moiré pattern will necessarily, or at least will with a high degree of probability, be created.

Moiré patterns are well known; and are

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PATENT SPECIFICATION

DRAWINGS ATTACHED

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ERRATA

SPECIFICATION No. 1,138,011

Page 1, line 55, *delete* "a"

Page 3, line 7, *after* "43" *insert* "used"

Page 3, line 116, *for* "100" *read* "500"

Page 5, line 3, *for* "it" (first occurrence) *read* "if"

Page 5, line 99, *for* "processe" *read* "processes"

THE PATENT OFFICE

10th June 1969

20 intaglio printing process in which the quantity of ink deposited on the bank note may be varied so as to create variations in shade or "tone" of the colour of the configurations on the bank note.

25 Developments in photo-mechanical reproduction methods using half-tone screening processes have made possible fairly good coloured reproductions of original documents. While persons very familiar with an original document such as a bank note (e.g. bank tellers) may be able to detect counterfeit reproductions even when skilfully made by photo-mechanical methods, persons making only casual inspection of such documents may not be able to detect a counterfeit document.

35 According to the present invention printing matter is provided with one or more patterns or configurations which prevent successful counterfeiting by half-tone screening reproduction processes by virtue of the intersection of the patterns on the printed matter with the rectangular screen grid pattern of the half-tone reproduction screen so as to make it substantially impossible to avoid

the case may be). It is the intention of the screen with the pattern on the original that results in the creation of a Moiré pattern, as will be more fully explained below. For example, assuming that a counterfeiter uses a half-tone screen having a grid spacing of 100 lines per inch, a bank note bearing a configuration of parallel straight lines having a spacing approximately 100 lines per inch will, if the angle of intersection of the screen lines with the bank note lines is small enough, produce a Moiré pattern. However, the bank note manufacturer cannot assume that the half-tone screen used by the counterfeiter will have any given line spacing nor can it assume that any given screen orientation will be used. According to the invention the original document is provided with one or more patterns selected so that, when light therefrom is intercepted by a rectangular half-tone screen, then regardless of the orientation of the screen selected by the counterfeiter a perceptible Moiré pattern will necessarily, or at least will with a high degree of probability, be created.

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discussed *inter alia* in the following publications:

Oster, *The Science of Moiré Patterns*, 1964

5 Oster and Nishijima, *Moiré Patterns*, 208 *Scientific American*, May 1963, p. 54

Oster, Wasserman and Zyverling, *Theoretical Interpretation of Moiré Patterns*, 54 *J. Optical Soc. Amer.* 169 (1964)

10 The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a block diagram illustrating a four-colour photo-mechanical process which may be used, for example, for the reproduction of a bank note or other printed matter,

Figure 2 is an expanded view of a screen for use in obtaining half-tone positives in the process illustrated in Figure 1,

20 Figure 3 is an arrangement of parallel lines of the same thickness and spacing as the parallel lines composing the screen shown in Figure 2,

Figure 4 illustrates the Moiré pattern produced when two parallel line configurations overlap at a slight angle;

Figure 5 shows an arrangement of concentric circles;

Figure 6 illustrates the Moiré pattern produced when a parallel line configuration overlaps a set of concentric circles;

Figure 7 shows a pattern of dots arranged in parallel rows;

Figure 8 shows a pattern of dots arranged in concentric circles;

Figure 9 shows a parallel line configuration in which the thickness and spacing of the lines continually decreases from left to right;

Figure 10 illustrates the Moiré pattern produced when the set of parallel lines in Figure 9 overlaps a set of parallel lines of uniform thickness and spacing at a slight angle;

Figure 11 shows an arrangement of concentric circles in which the thickness and spacing of the circles decreases from the center outwards;

Figure 12 shows the Moiré pattern which results when the pattern shown in Figure 11 overlaps a pattern of parallel straight lines at a slight angle;

Figure 13 shows a pattern of radial lines;

Figure 14 shows the Moiré pattern which results when two patterns of the type shown in Figure 13 overlap at a slight displacement one from the other; and

Figure 15 illustrates a simplified bank note utilizing the principles of the present invention.

60 It is the purpose of the present invention to make it more difficult for counterfeiters using photographic colour-separation techniques to obtain a good reproduction of an original piece of printed matter, for example

a bank note. In order that the invention may be appreciated, a discussion of colour-separation photo-mechanical reproduction method follows.

Figure 1 illustrates in block diagram form an exemplary four-colour photo-mechanical reproduction method. An original document 11 (produced, for example, by an intaglio printing process) is photographed through appropriate colour filters 13, 15, 17 and 19 and suitable colour correction masks 21, 23, 25 and 27 to obtain yellow, magenta, cyan and black continuous tone negatives 29, 31, 33 and 35. (While a variety of different colour separations are possible, the most commonly used colour separations are yellow, magenta, cyan and black).

In order that the colours and the tonal variations in them may be effectively simulated, the continuous tone negatives are normally screened to obtain half-tone colour separations. Each printing plate may be manufactured using as a pattern a half-tone positive (or negative, as the case may be) for the corresponding colour separation. The half-tone positive is ordinarily obtained by screening the continuous tone negative with a screen which usually consists of a rectangular grid such as the greatly magnified grid shown in Figure 2. Ordinarily, such a grid is designed so that the total area of the holes is equal to the total area of the lines, and to that extent Figure 2 misrepresents reality. It will be understood that screens actually used in practice have line spacings of the order of 100 to 200 lines per inch, although line spacings outside this range are possible.

Because the continuous-tone negative is converted into a half-tone positive composed of a regular dot pattern, the variation in tone on the colour separation is transformed into a variation in the size of the dots in any given area of the colour in question. Thus a dark, solid tone will be translated into a dot pattern with a high percentage of solid content which will be perceived by the eye as a deep shade of the colour in question. For lighter shades of the colour, the dot pattern in the half-tone positive will comprise smaller dots, and will be perceived by the eye as an integration of the total area of the dots bearing colour and the areas not bearing colour, and therefore as a lighter shade of the colour in question.

As stated above, four colour separations are ordinarily made.

If the half-tone screens for the four colours were all aligned in uniform orientation, this might result in a reproduced document bearing perceptible Moiré patterns. Accordingly, to minimize this effect, it is customary to arrange the half-tone screen for each colour at an orientation which differs from that used for the other colours. The standard screen orientations are, with respect to a

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horizontal line pointing to the right as a 0° reference, 90° for the half-tone screen 37 used for the yellow separation, 75° for the half-tone screen 39 used for the magenta separation, 105° for the half-tone screen 41 used for the cyan separation, and 45° for the half-tone screen 43 for the black separation. The resulting half-tone positives 45, 47, 49 and 51 will thus have differently orientated dot patterns and the printing plates 53, 55, 57 and 59 obtained from the half-tone positives will correspondingly be provided with differently-orientated dot patterns for printing the document. (The reproduced document 69 is printed successively by the four printing plates 53 to 59 in printing units 61, 63, 65 and 67, respectively).

According to the invention, the original document 11 is provided with a pattern which, when screened by the half-tone screens 37 to 43, results in the production of at least one half-tone positive which necessarily includes at least one Moiré pattern. The Moiré pattern is the product of the interception by the half-tone screen of light emanating from the pattern on the original document 11. In other words, the invention makes use of the known principle that two regular patterns may intersect in such a way as to form a Moiré pattern. The presence of such Moiré pattern on the reproduced document indicates that the reproduced document is counterfeit.

The following discussion relates to patterns which may be used on the original document 11 to create a Moiré pattern after screening.

Figure 3 shows an arrangement of parallel straight lines having the same spacing as the horizontal parallel lines in the rectangular grid shown in Figure 2. When two sets of parallel lines as shown in Figure 3 overlap at a slight angle (from a fraction of a degree to several degrees), a Moiré pattern is produced, as Figure 4 illustrates. The Moiré pattern consists of the vertical parallel bands formed by the points of intersection of the two sets of parallel lines. It will be appreciated that when two sets of parallel lines intersecting at right angles form a grid such as that shown in Figure 2, a set of parallel lines of the same spacing at a slight angle to either the vertical set of parallel lines in the grid or to the horizontal set of parallel lines in the grid will form a Moiré pattern.

A great number of configurations other than patterns of parallel lines will produce Moiré patterns when a rectangular grid is superimposed upon the pattern in question. As another example, a pattern composed of concentric circles such as that shown in Figure 5, when intersected by a pattern of parallel straight lines, produces a Moiré pattern such as that shown in Figure 6. The Moiré pattern in this case consists of approximately parabolic curves tangent to one another at the center of the concentric circle pattern. It

will be understood that a rectangular screen grid composed of two intersecting sets of parallel lines would produce an additional set of parabolic curves when intersecting the set of concentric circles shown in Figure 5; however, for the purpose of simplifying the drawings only one set of parallel lines in the rectangular grid has been shown.

If the original document 11 contains an appropriate pattern, then upon screening in the half-tone photo-mechanical reproduction process, a Moiré pattern will occur on the reproduced document. A perceptible Moiré pattern, i.e. a Moiré pattern large enough to be readily apparent to a person handling the document if even a casual glance is taken at the document, is preferred, and choice of patterns on the original should be made accordingly.

To exhaust the list of patterns which, when intersected by a rectangular grid, produce Moiré patterns is a practically impossible task. The most commonly-illustrated Moiré producing patterns are patterns of parallel curves and patterns of curved or straight lines having an obvious geometrical regularity.

It is apparent that not only line patterns but also patterns of dots may give rise to Moiré patterns when intersected by a rectangular or other grid. For example, the series of parallel lines shown in Figure 3 may be approximated by a dot pattern in which the dots lie on the locus defined by the parallel lines. Such a pattern is shown in Figure 7. Likewise, the dots might lie on the locus defined by the circles shown in Figure 5; such a pattern is shown in Figure 8. Accordingly, an arrangement of dots in which there is some geometrical regularity may, when intersected by a rectangular grid, form a Moiré pattern. A special example of such an arrangement is a design picture, portrait, etc. in dot pattern form, obtained by the use of a half-tone screen.

Screen grids used in the photo-mechanical reproduction process described with reference to Figure 1 may as stated above, have line spacings of the order of 100 to 200 lines per inch in commercial practice, although line spacings outside this range, say 75 to 100 lines per inch, are possible. However, if a line pattern on the original document 11 is composed of lines having a spacing that differs by a sufficient degree (say 15%, the figure depends on the pattern) from the spacing of the lines on the screen grid used by the photographer, it is possible that no Moiré pattern may result in the reproduction 69. Accordingly, to guard against the possibility that a counterfeiter may use a screen grid of a different line spacing from that of the line pattern applied to the original document 11, one of two alternative precautions should be taken. One precaution is to provide the document 11 with a number of patterns each

having a different line spacing so that there is a high probability of having at least one line spacing that will intersect a screen grid used by the counterfeiter to produce a perceptible Moiré pattern. The alternative is to use in a single pattern a varying line spacing. Such a pattern is illustrated in Figure 9, which shows an arrangement of parallel straight lines in which the spacing of the lines diminishes from left to right on the pattern. The intersection of a set of parallel lines of uniform spacing with the pattern shown in Figure 9 produces the Moiré pattern shown in Figure 10. It is seen that the most easily perceived Moiré pattern occurs where the thickness and spacing of the lines in the parallel line arrangement of Figure 9 is identical or close to that of the superimposed pattern of regularly spaced parallel lines of uniform thickness. However, it will be observed that other line spacings also produce Moiré patterns. It has been found experimentally that Moiré patterns are mostly likely to result when a simple ratio of two small integers defines the relationship between the spacing of the lines in the pattern in question to the spacings of the lines in the regularly spaced rectangular screen grid. For example, where the spacing of the lines in the grid is 200 lines per inch, it will be expected that superimposed parallel line spacings of the order of 50, 100, 200 and 400 lines per inch will result in the creation of a Moiré pattern. In the intaglio printing process, spacings up to 200 lines per inch can be readily achieved.

Another problem with respect to the photo-mechanical reproduction process is that the screen used by the counterfeiter may be oriented at any angle. This suggests a further precaution that may be taken by the manufacturer of the original document *11*; namely, to provide patterns on the bank note having different orientations. Because the 90°, 75°, 45° and 105° angles of the screens shown in Figure 1 are standard, an obvious precaution is to ensure that there is at least one pattern on the original bank note that will intersect at a small angle each of the screen orientations. This can be accomplished by providing the original document *11* with a number of parallel line patterns, each oriented at a different angle so as to intersect at a sufficiently small angle at least one set of parallel lines used in the half tone screens, no matter what orientation of the screens the counterfeiter may choose to obtain his half-tone positives.

An alternative method of guarding against the possibility of varying screen orientations is to provide a pattern which intrinsically provides varying angles of intersection. Such is the pattern of Figure 5, because there will always be at least some portion of the circles which intersect the lines of the screen grid

at a small angle thereby to form a Moiré pattern. Another example of such a pattern is the radial line configuration shown in Figure 13.

In order to combine the two advantages afforded by a different line spacings and intrinsically varying orientation, a pattern such as that shown in Figure 11 may be used. This is a pattern of concentric circles in which the line spacing decreases from the center outwards. The Moiré produced when this figure is intersected by an arrangement of parallel straight lines is shown in Figure 12.

Another example of a pattern of lines which makes use of varying line spacing and also makes use of different orientations of lines within the pattern is that shown in Figure 13, which is a pattern of radial lines emanating from a common origin and increasing in thickness and spacing from the center outwards.

In one form of printed matter with coloured patterns whose elements are lines, the patterns having a plurality of orientations and a plurality of spacings, the spacing of at least one of the line patterns of the printed matter having an orientation within five degrees of any given orientation in the said pattern in relation to the spacings of the lines of the screen grid will be defined by the product of a line spacing in the range 75 to 500 lines per inch and the ratio of two positive integers each of which is less than 6.

In for example printed matter wherein the pattern or configuration is a two-dimensional configuration of coloured patterns the elements of which are lines, having a predetermined regularity and a line spacing in the range 75 to 500 lines per inch, the several patterns having orientations such that at least one pattern includes a plurality of lines which intersect any given line superimposed upon the printed matter at an angle of less than 10°, and having spacings such that there will be at least one pattern having a line spacing which differs by no more than 15% from a line spacing in the range 75 to 500 lines per inch.

The foregoing discussion of the production of Moiré patterns by a screen grid with a regular configuration of lines, dots or the like is incomplete in that only the black and white effects of the superimposition have been described with reference to the accompanying drawings. However, it is frequently found not only that Moiré patterns are produced but that colour distortions are produced in the reproduced composite colour print which may be even more apparent than the Moiré patterns. Unfortunately, black and white drawings cannot adequately illustrate such colour distortion.

In the foregoing discussion, it has been assumed that a rectangular grid is used to screen the continuous tone negatives, and ex-

amples of patterns for use on original documents have been given on the basis of this assumption. However, it is contemplated that a screen having some other configuration will be used by the counterfeiter, the choice of patterns for use on the original document may have to be modified so as to maximize the probability of creating a Moiré pattern on the reproduced document.

10 It has been found that many of the foregoing patterns, and especially the pattern of Figure 13, or modifications of this pattern affords another anti-counterfeiting advantage when reproducing an original document without using a screening process in the case in which the pattern is superimposed on itself on the reproduced document by successive printings in more than one colour. If the patterns do not overlap identically when the reproduction is printed, a Moiré pattern will result because of the non-alignment of the superimposed printings of the pattern on the reproduced document. Figure 14 shows the Moiré pattern which results when two patterns of the type shown in Figure 13 overlap with slight displacement.

A simplified bank note to which a number of patterns have been applied in accordance with the present invention is shown in Figure 15. Several groups of parallel lines may be seen. For example, the diamond and circle pattern reproduced twice on the bank note comprises three sets of parallel lines oriented at approximately 0°, 75° and 105° respectively. These orientations have been chosen to correspond with the standard orientations of the horizontal portion of the yellow colour-separation screen 37 and the vertical portion of the magenta and cyan screens 39 and 41 discussed with reference to Figure 1. The numeral 5 in the center of the bank note is lined with parallel lines at 135° thereby to correspond to the horizontal lines in the black separation half-tone screen 43 shown in Figure 1. Another set of parallel lines is illustrated in the upper left hand corner of the bank note and it will be noted that this pattern includes variable line spacing, the spacing and thickness of lines decreasing from top to bottom in order to make the pattern effective against different screen spacings in the half-tone screens used by the counterfeiter. The choice of horizontal orientation of this pattern is not a preferred choice, however, because in the normal upright position of the bank note, only the yellow screen will intersect this pattern at a slight angle and imperfections in the yellow portions of the bank note are ordinarily least perceptible.

60 Patterns of portions of concentric circles are shown in the lower left and upper right corners of the bank note. The concentric circle pattern in the upper right corner is composed of lines of uniform width and spacing, and therefore would not be effective

against all possible half-tone screen grids. However, if a plurality of concentric circle patterns of different line spacings were included in the bank note, this deficiency could be overcome. The pattern at the lower left of the bank note assists in overcoming the deficiency by use of continually varying line spacings, the spacing decreasing from the corner of the bank note inwards.

Along the bottom of the bank note and at the lower right hand corner are configurations of lines in which spacing and orientation continually vary. Straight lines are used in the symmetrical left and right hand side bottom patterns but the center bottom pattern, bearing the two signatures, is shown composed of a regular array of wavy lines rather than straight lines.

It will be appreciated that in order to give artistic effect to a document such as a bank note, the patterns used on the note would not ordinarily be confined to simple combinations of circles, straight lines and other regular curves. However, many configurations of lines bearing a sufficient degree of regularity may be used. It is possible to combine regular line configurations even in representations of physical objects such as portraits and scenes from nature.

WHAT WE CLAIM IS:—

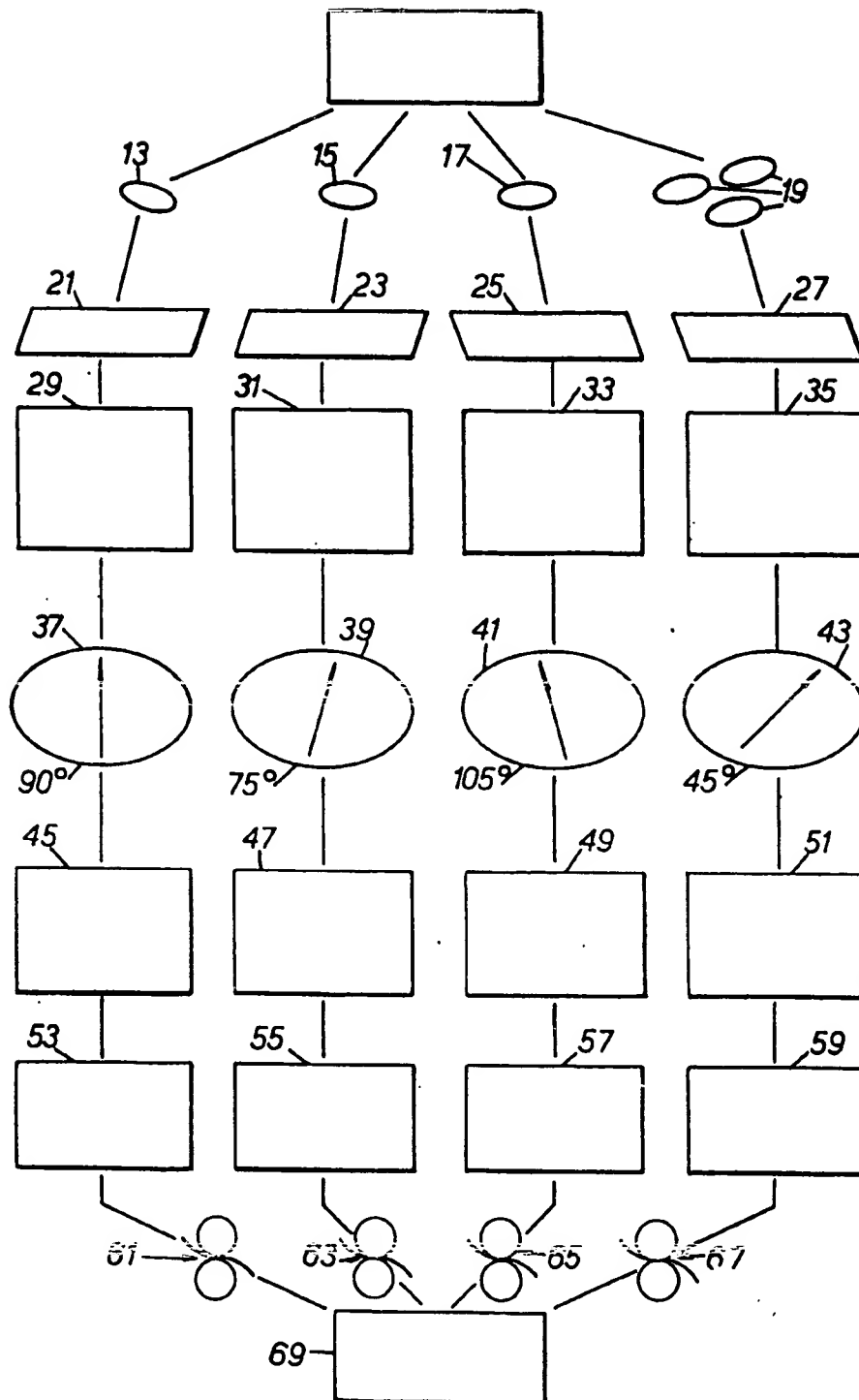
1. Printed matter provided with one or more patterns or configurations which prevent successful counterfeiting by half-tone screening reproduction process by virtue of the intersection of the patterns on the printed matter with the rectangular screen grid pattern of the half-tone reproduction screen so as to make it substantially impossible to avoid creating a Moiré pattern on the reproduced document.
2. Printed matter according to claim 1 wherein the pattern or configuration is a coloured configuration composed of elements the orientation and spacing of which are such that when light from the printed matter is intercepted by a rectangular grid having line spacings in the range 75 to 500 lines per inch, a perceptible Moiré pattern is produced.
3. Printed matter according to claim 1 wherein the pattern or configuration is a two-dimensional coloured configuration the elements of which are lines and whose orientation and line spacing are such that reproducing the printed matter by means of a colour-separation method using a half-tone screen comprising a rectangular grid pattern having uniform line spacings in the range 75 to 500 lines per inch, creates a perceptible Moiré pattern on the printed reproduction.
4. Printed matter as claimed in any of the preceding claims in which the spacing of the elements in the pattern or configuration is of the same order as the spacing of the lines in the rectangular grid.

5. Printed matter as claimed in any one of the previous claims wherein the pattern or configuration is a two-dimensional regular configuration of coloured patterns whose elements are lines, the patterns having a plurality of orientations and a plurality of spacings, the spacings of at least one pattern of lines of the printed matter having an orientation within five degrees of any orientation in the said plurality and in relation to the spacings of the lines of the screen grid being of the order of the product of any given line spacing in the range 75 to 500 lines per inch and the ratio of two positive integers each of which is less than 6.
6. Printed matter as claimed in any one of the previous claims, wherein the pattern or configuration is a two-dimensional configuration of coloured patterns the elements of which are lines, having a predetermined regularity and a line spacing in the range 75 to 500 lines per inch, the several patterns having orientations such that at least one pattern includes a plurality of lines which intersect any given line superimposed upon the printed matter at an angle of less than 10° , and having spacings such that there will be at least one pattern having a line spacing which differs by no more than 15% from a line spacing in the range 75 to 500 lines per inch.
7. Printed matter as claimed in any one of claims 2 to 6 in which said range is 100 to 300 lines per inch.
8. Printed matter as claimed in any one of claims 2 to 7 in which the spacing of the elements varies progressively throughout the pattern or configuration.
9. Printed matter as claimed in any one of the preceding claims in which the pattern or configuration contains several patterns each composed of uniformly-spaced elements, each pattern having an element spacing different from the element spacings in the other patterns.
10. Printed matter as claimed in any one of the preceding claims wherein the elements are oriented so as to intersect at a small angle the projection on the printed matter of one of the sets of parallel lines in the said grid.
11. Printed matter as claimed in any one of the preceding claims in which the orientation of the elements of said pattern or configuration is continuously varying.
12. Printed matter as claimed in claim 11 in which the said pattern or configuration includes a plurality of closely spaced parallel curves.
13. Printed matter as claimed in claim 12 in which the parallel curves are circles or arcs of circles.
14. Printed matter as claimed in any one of the preceding claims 1 to 10 in which the elements of the pattern or configuration form a plurality of patterns each having elements of uniform orientation, the elements of each pattern having an orientation different from the orientation of the elements in the other patterns.
15. Printed matter as claimed in any one of the preceding claims 1 to 10 in which the orientation of the elements of the pattern or configuration is continually varying.
16. Printed matter as claimed in any one of the preceding claims 1 to 10 wherein the elements of the pattern or configuration are straight lines.
17. Printed matter as claimed in any one of the preceding claims 1 to 6 wherein the pattern or configuration includes a pattern of radial lines.
18. Printed matter as claimed in claim 1 or 2 in which the pattern or configuration is composed of a plurality of regularly spaced dots.
19. Printed matter as claimed in claim 18, in which the pattern or configuration is a dot pattern obtained from a design by means of a half-tone screen.
20. Printed matter substantially as herein described with reference to the accompanying drawings.

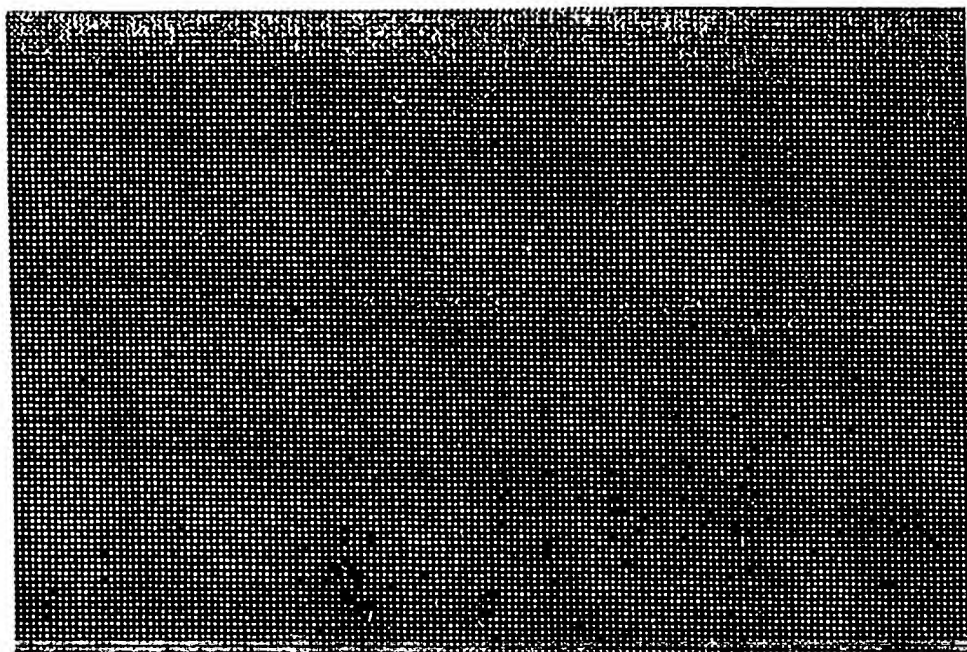
E. R. ROYSTON & CO.,
Agents for the Applicants.
Chartered Patent Agents,
Tower Buildings,
Water Street,
Liverpool, 3.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1968.

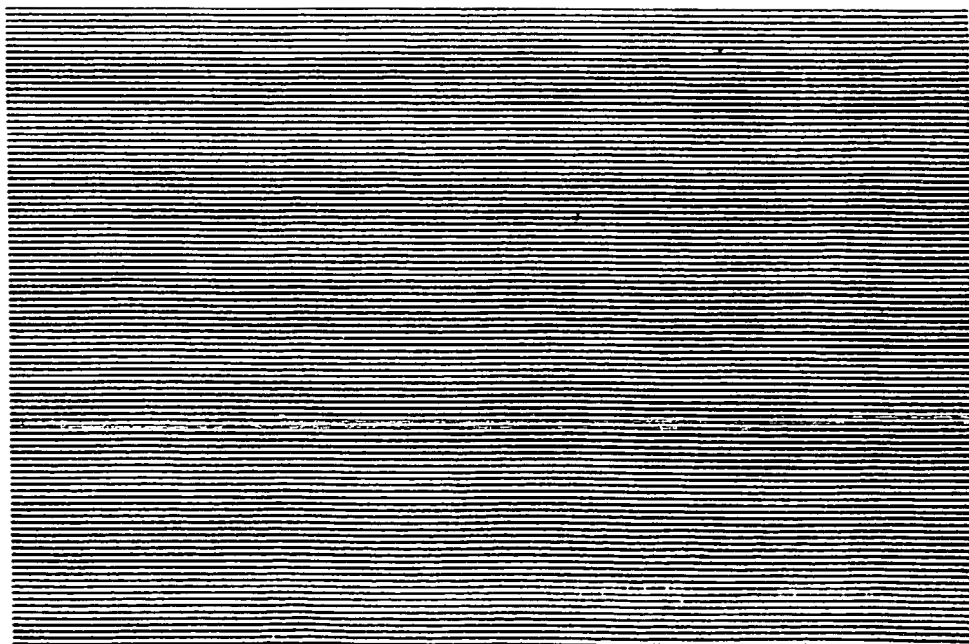
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--FIG. 1.--



—FIG. 2.—



—FIG. 3.—

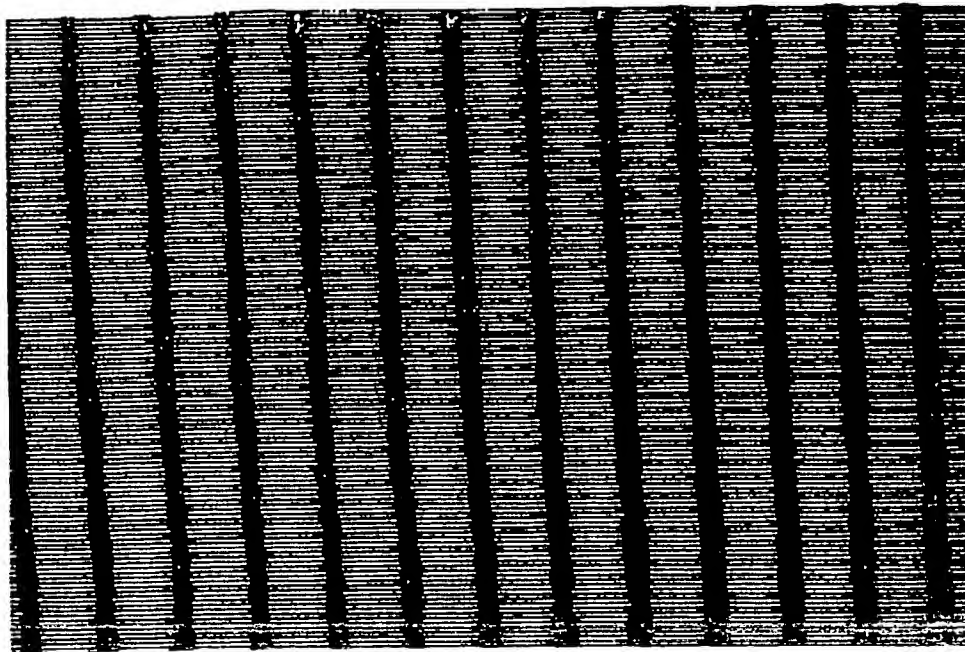
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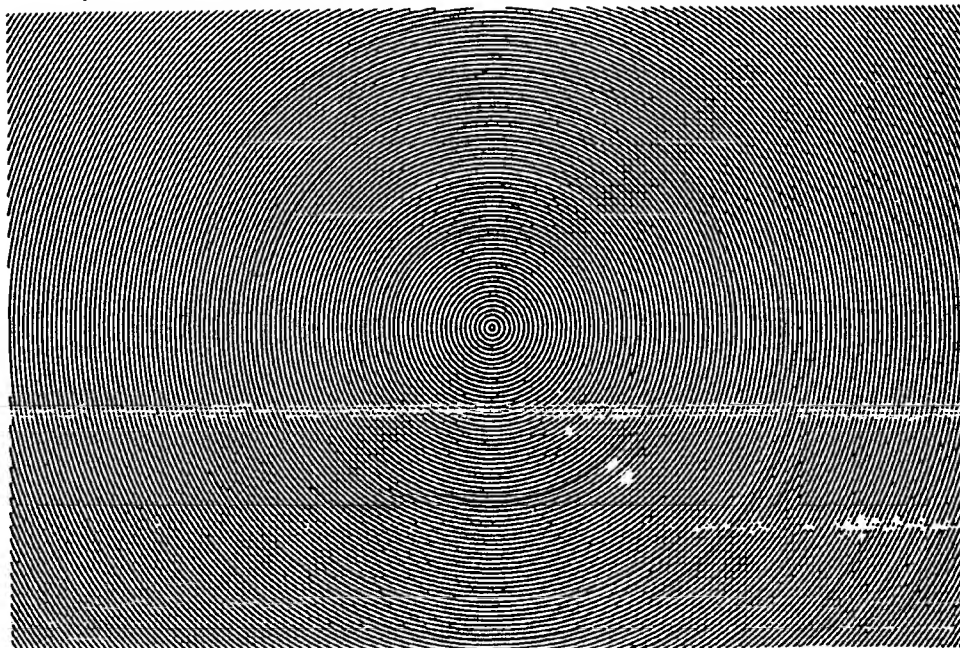
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the Original on a reduced scale*

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—FIG. 4.—



—FIG. 5.—

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the Original on a reduced scale

SHEETS 2 6 3



FIG. 2.

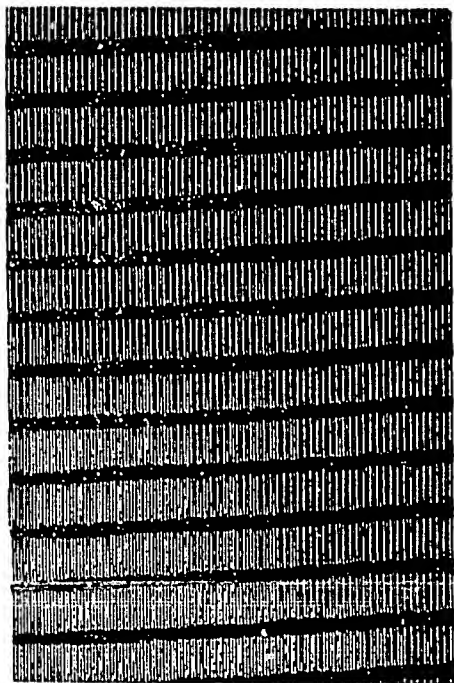
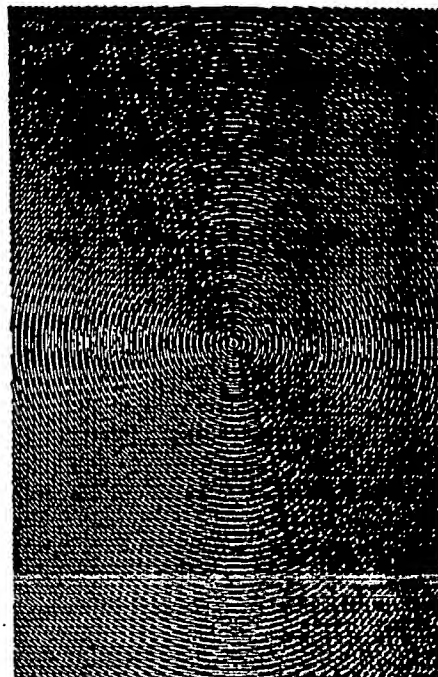
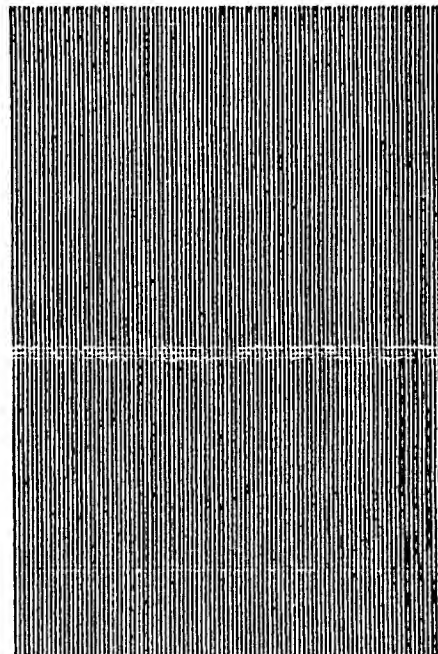
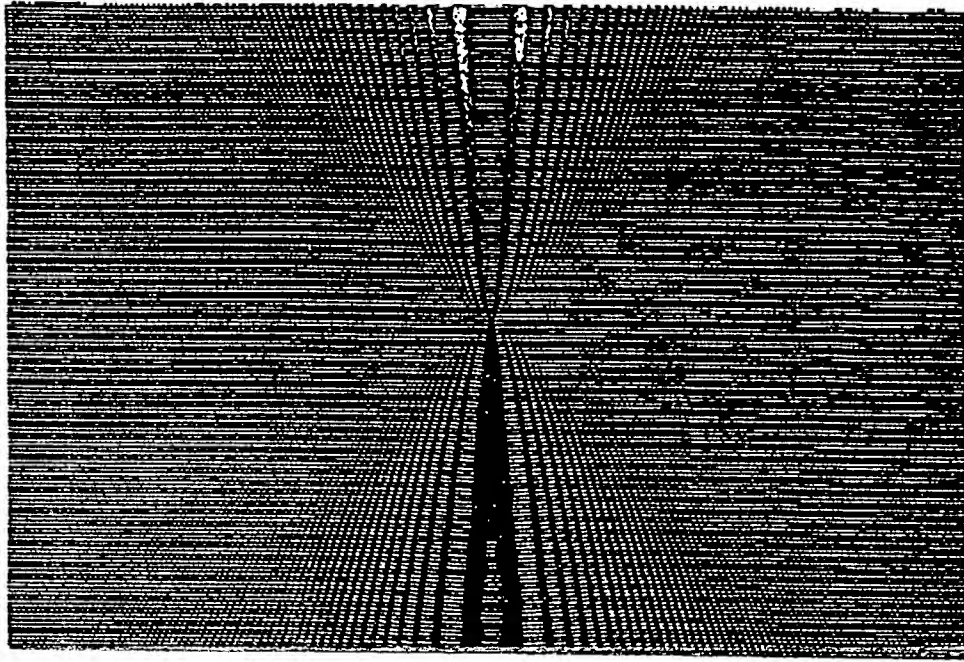
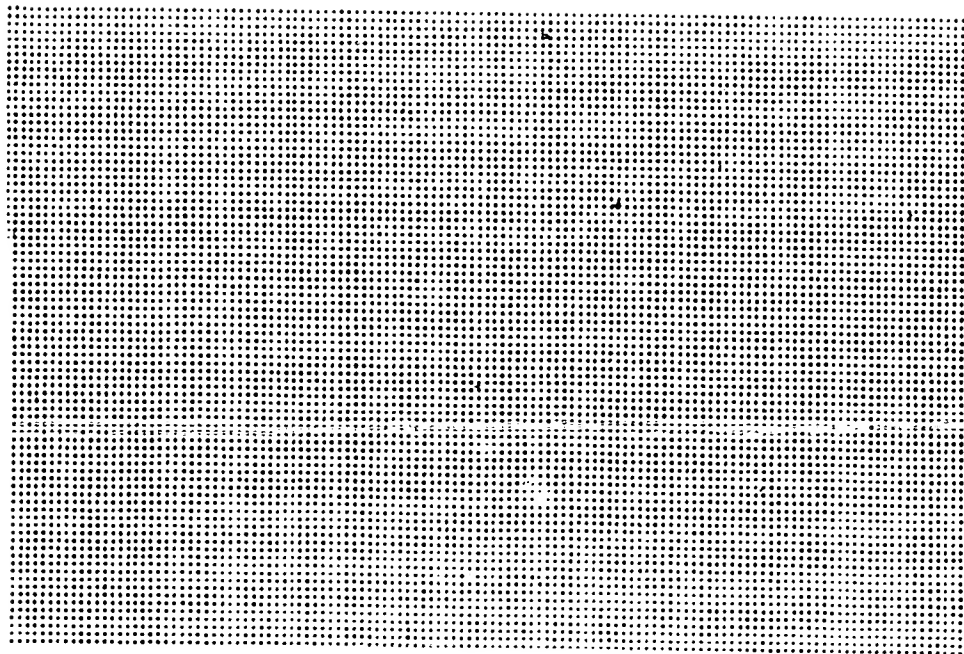


FIG. 4.





— FIG. 6. —



— FIG. 7. —

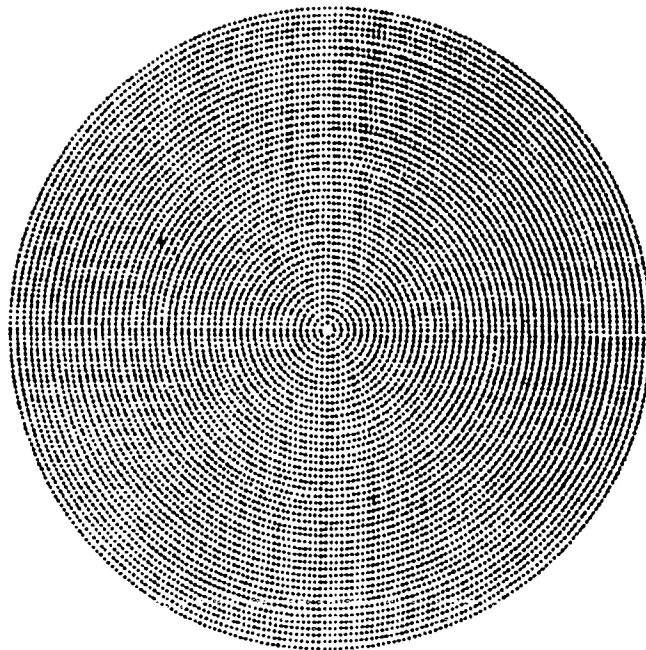
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COMPLETE SPECIFICATION

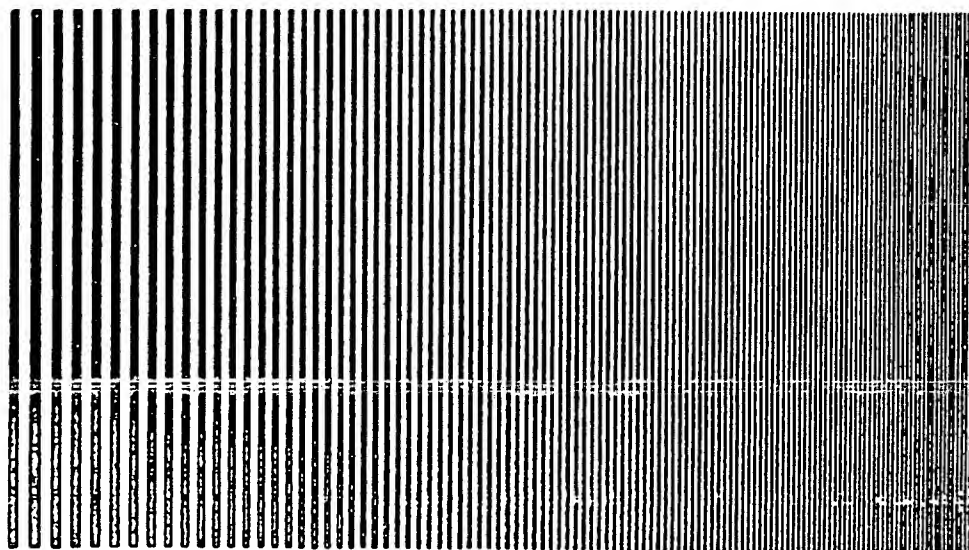
2 SHEETS

*This drawing is a reproduction of
the Original on a reduced scale*

SHEETS 4 & 5

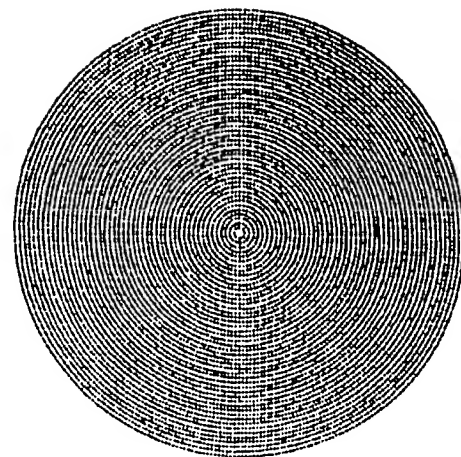


—FIG. 8.—



—FIG. 9.—

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 SHEETS 4 & 5



—FIG. 8—

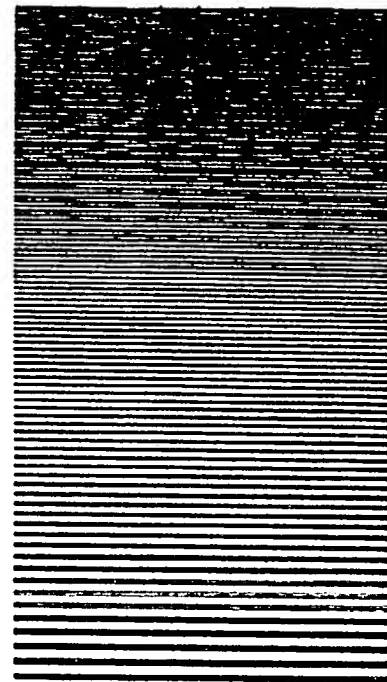
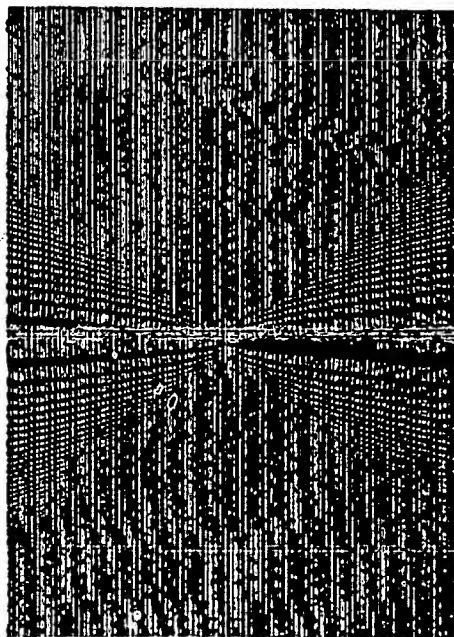
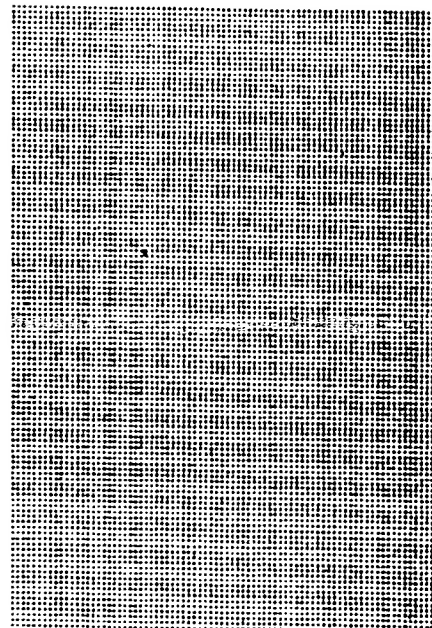
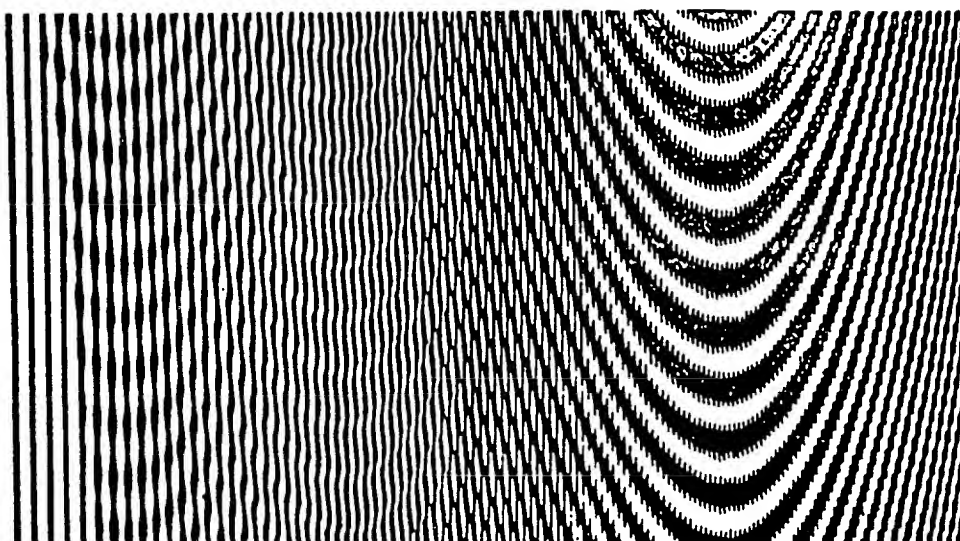


FIG. 9

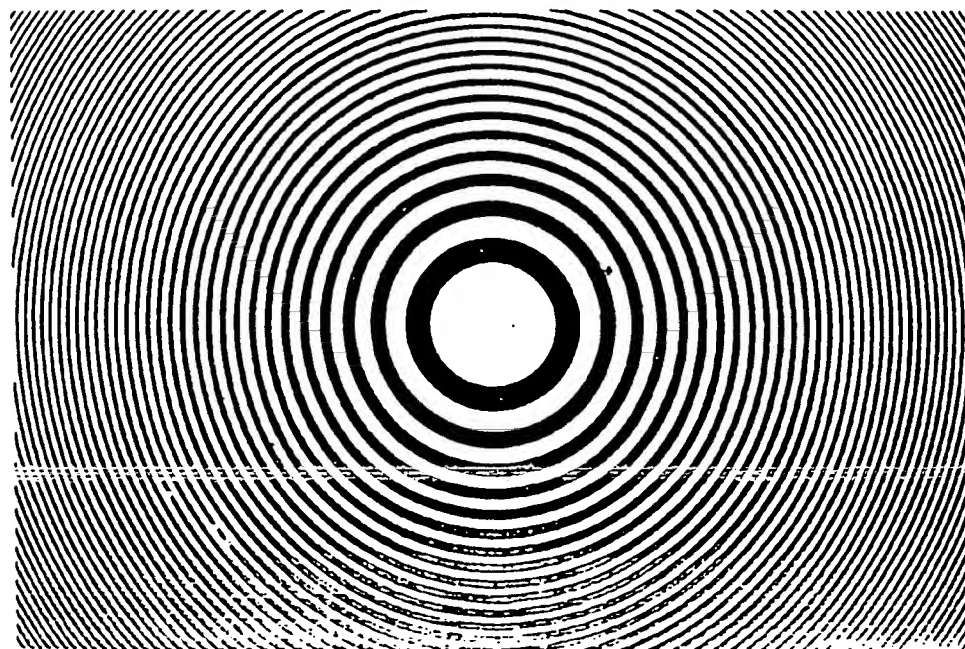


—FIG. 6—





—FIG. 10.—



—FIG. 11.—

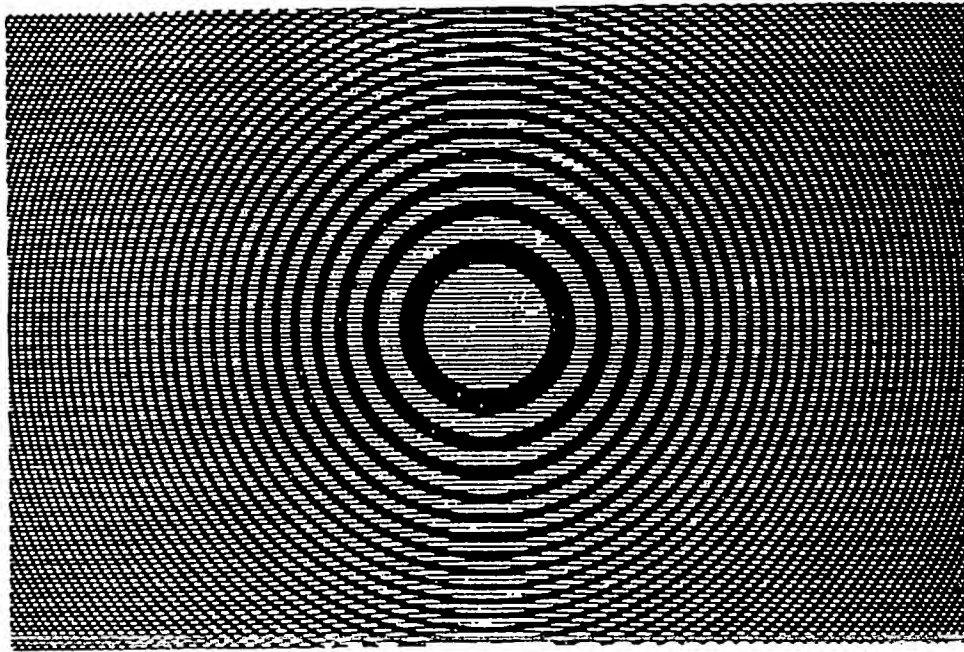
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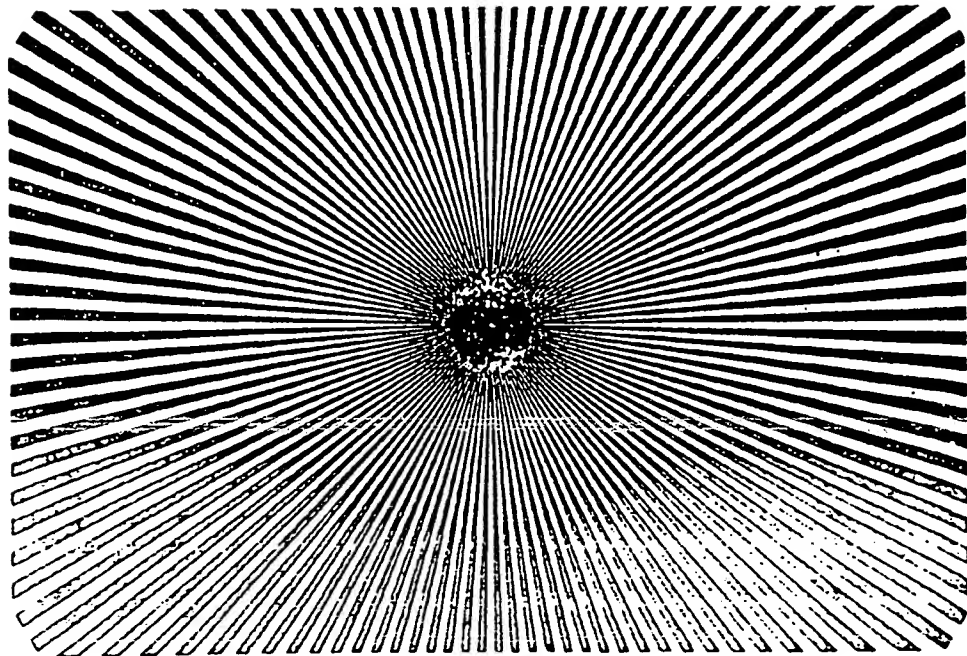
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SHEETS 6 & 7

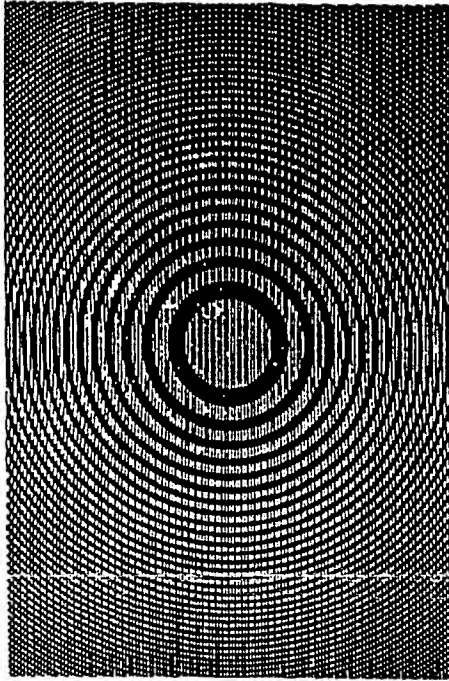


—FIG. 12.—

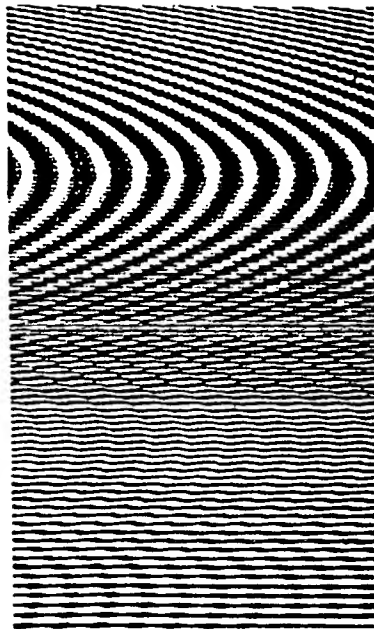
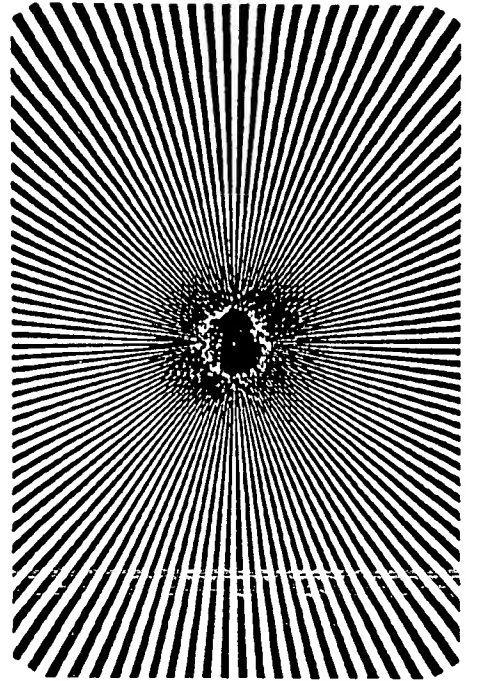


—FIG. 13.—

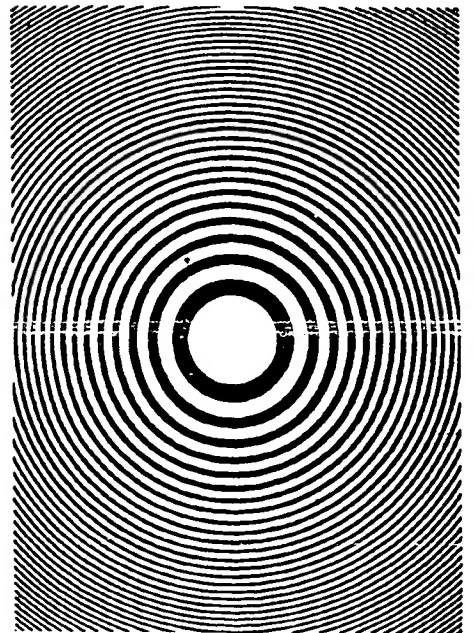
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 SHEETS 6 & 7



—FIG. 12.—

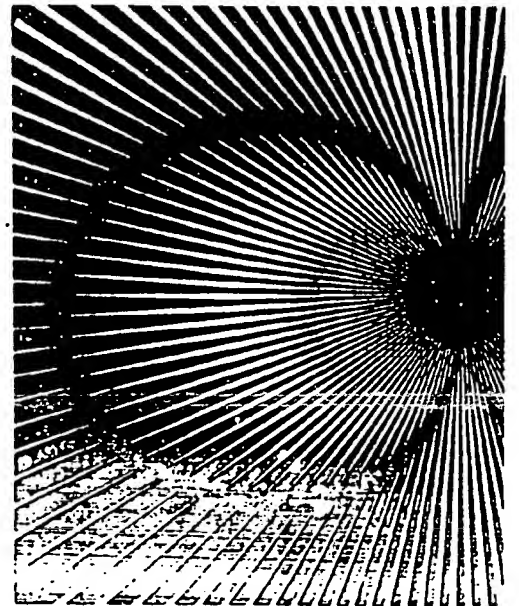


—FIG. 10.—





—FIG. 15.—



—FIG. 14.—

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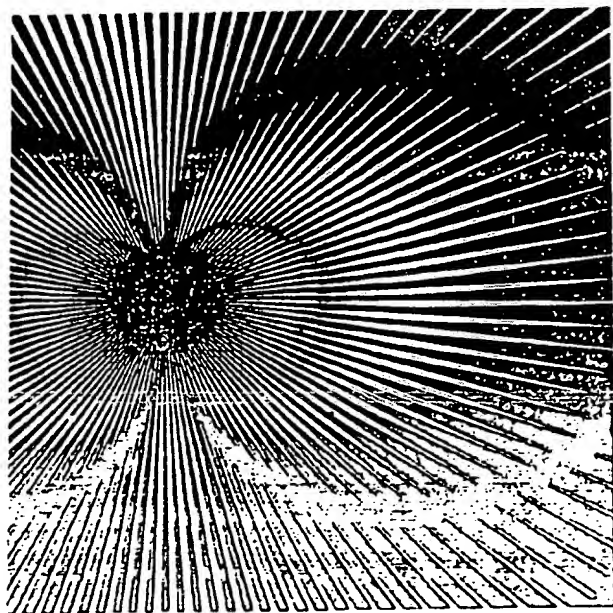
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SHEET 3



FIG. 15.—



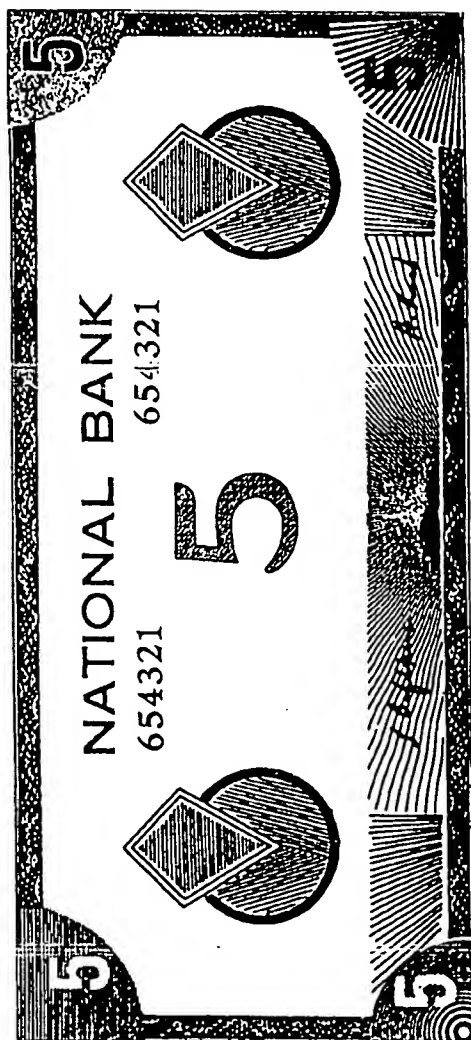
—FIG. 14.—

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8 SHEETS

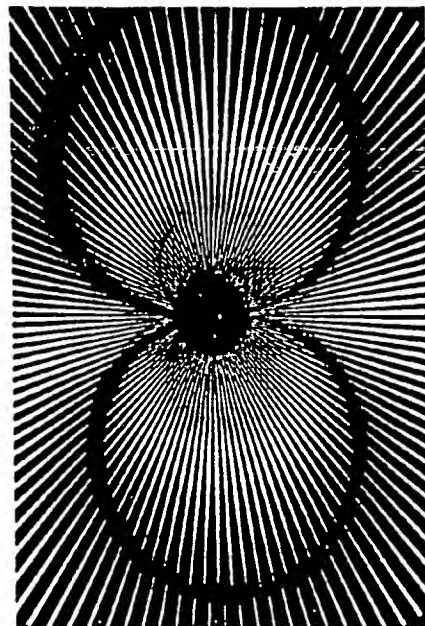
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SHEET 8



—FIG. 15.—



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